Nexus: Planning Tomorrow, Today

John Jaap & Patrick Meyer

Missions Operations Laboratory
Marshall Space Flight Center
National Aeronautics and Space Administration
John.Jaap@nasa.gov

Abstract

To prepare for future human space flight programs, the Mission Operations Laboratory (MOL) at the Marshall Space Flight Center (MSFC) has been investigating new planning and scheduling paradigms. To support and prove this investigation, MOL technologists have developed a working prototype of a scheduling system to support the new paradigms. The new planning and scheduling system is called Nexus and has a web site at http://nexus.nasa.gov/. Nexus is based on a comprehensive modeling schema to capture all scheduling requirements typical to human space missions, an incremental scheduling engine tailored to the modeling schema, and remote access (including Personal Data Assistant (PDA) access) to the scheduling system. This paper describes the proposed paradigm shift and the enabling software. It also describes a typical Nexus demonstration which emphasizes how it works, how it enables the paradigm shift, and possible applications. Demonstrations include access to the full functionally of Nexus from a personal computer and access to limited functionally via a PDA. An appendix includes a description and screen shots of the demonstrations.

A Paradigm Shift for Planning and Scheduling

The current state-of-the-art in modeling methodologies and scheduling engines results in a linear paradigm with knowledge contributed by task experts, vehicle experts, and scheduling engine experts. This paradigm requires significant effort and flow time. The task experts often struggle to enter their requirements using a language that is limited – often resorting to notes to fully describe their requirements. The vehicle and hardware experts then convert and augment this knowledge to further prepare the models for scheduling. The scheduling team then feeds the models to the scheduling engine. Since the models are incomplete, the team often has to "steer" the scheduler to produce an acceptable schedule.

Nexus enables a streamlined paradigm. The vehicle experts would enter the system and hardware constraints independently of the task knowledge. The task experts would enter the task requirements. The comprehensive modeling schema would allow them to specify all of the task requirements without resorting to notes for the scheduling team; these models would be ready for automatic scheduling. Having models that express all the constraints allows the scheduling engine to operate automatically without human intervention.

The Nexus Project

Comprehensive Modeling

The capability of a scheduling system is dependent on the quality of the input – the models of the tasks to be scheduled. The features of Nexus models are –

- Decomposition into salient components— Modeling is based on activities and sequences.
- Equipment modes— Implicit resource requirements are defined by equipment mode models, closely representing the real world.
- Intuitive and rich expression of the relationships between components— Modeling employs common-sense modeling of temporal relationships using everyday concepts like sequential, during, and overlap. Innovative modeling of the continuance of resource usage between tasks, the fragmentation of tasks, and minimal percent coverage are included.
- Public Services— Modeling also includes the concept of public services, models that are scheduled at the request of another model.
- Experiment flexibility— Variable timing can be modeled at all levels. Alternate resources and sequences of elements can be modeled.
- Representation of nuances of the tasks— Even nuances, such as locking in alternate resources and one-to-one relationships are available.

Scheduling Engine

Nexus uses the Scheduling Algorithm for Temporal Relation Networks (SATRN) as an "incremental" scheduler. SATRN processes a single request (adding one or more tasks to the timeline) and then waits for another request.

SATRN converts the temporal relations of a sequence to time bounds on the sequence entities (embedded

sequences or activities). As each entity is scheduled, the bounds on not-scheduled entities are shrunk. An activity's requirements are checked by a depth-first search. Variable activity durations are utilized to stay within the time bounds. When an entity cannot be scheduled, smart backtracking and reordering is used to unshrink the bounds on hard-to-schedule entities. Backtracking is also used to explore alternate requirements ("1-of" groups, scenarios, optional entities, and relationships to existing entities with multiple instances).

Configurations

- Multi-user— Multiple users can simultaneously build a single timeline through a centralized scheduling server. Users only need a computer and an Internet connection – even astronauts on orbit. This can enable those closest to the tasks being performed to enter their requirements and build the best schedule for themselves.
- Personal Data Assistant (PDA)— Crew self-planning is another configuration of Nexus. Astronauts could plan their own day rather than be tied to the traditional remote planning done today.
- Standalone— One user, on a single computer, working on one schedule is the classical configuration for planning and scheduling systems. This configuration would be the simplest setup of Nexus.

Applications of Nexus

Cost-savings applications

Nexus can allow the customers to produce their own timelines. The customers have the best knowledge of their scheduling requirements and know when a timeline meets their needs. Nexus enables them to perform their own scheduling because –

- The use of an incremental scheduler prevents the action of one user from impacting another user.
- The Nexus modeling schema captures all the requirements without resorting to artificial resources or difficult rule expressions.
- By submitting incrementally and getting immediate feedback from the scheduling engine, the users become virtual experts on modeling and scheduling

Cost reduction is realized by reducing the size of the scheduling cadre and the flow time required to produce a schedule.

Crew-autonomy application

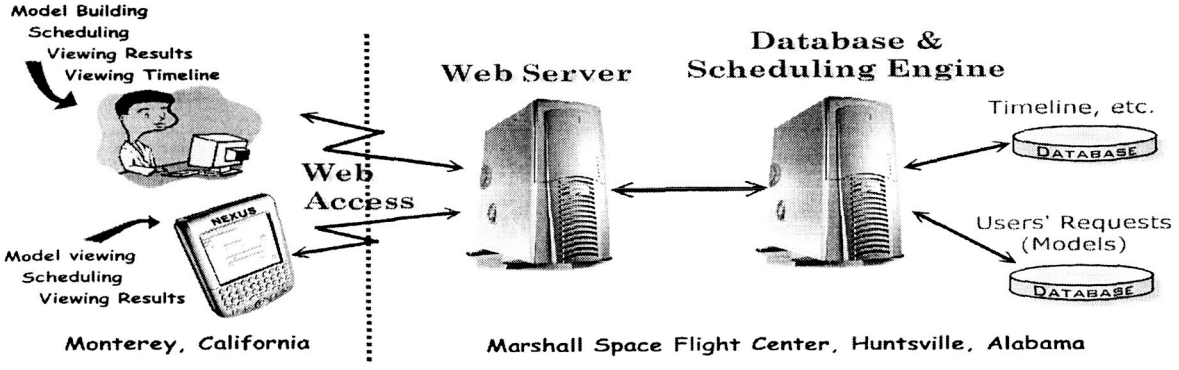
Nexus can allow the astronauts in space to schedule their own activities. Crew autonomy is essential as we explore further from home. The astronauts are aware of their situation and understand their needs and desires better than anyone. The light-time delay (up to 20 minutes from Mars) makes normal conversations with the earth-based support team impossible. The ground support team would build the baseline models and baseline schedule and upload it to the in-situ installation of Nexus. The astronauts would add to or delete from the timeline as desired. Ground support would also be able to modify the timeline using the remote access features of Nexus.

Proposed Demonstration

Demonstrations have two parts –

- Multi-user configuration— A personal computer is connected, via the internet, to a web server at MSFC. Typical demonstrations include building and editing models, submitting scheduling request, reviewing the results of the request, and viewing the complete timeline.
- Personal Data Assistant— A PDA is connected, via a wireless access point and the internet, to a web server at MSFC. Demonstrations include submitting a pre-prepared scheduling request and viewing the results.

The figure below shows the demonstration architecture. The appendix includes screenshots of the both demonstration parts.



Appendix to
Nexus: Planning Tomorrow, Today

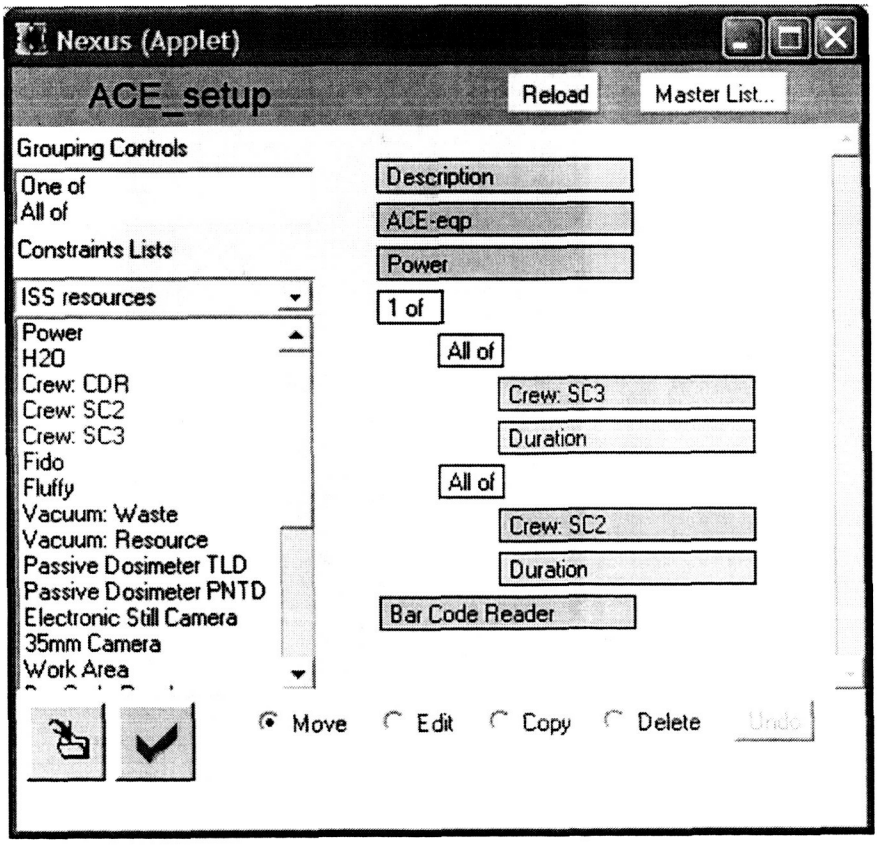
John Jaap & Patrick Meyer

Missions Operations Laboratory
Marshall Space Flight Center
National Aeronautics and Space Administration
John.Jaap@nasa.gov

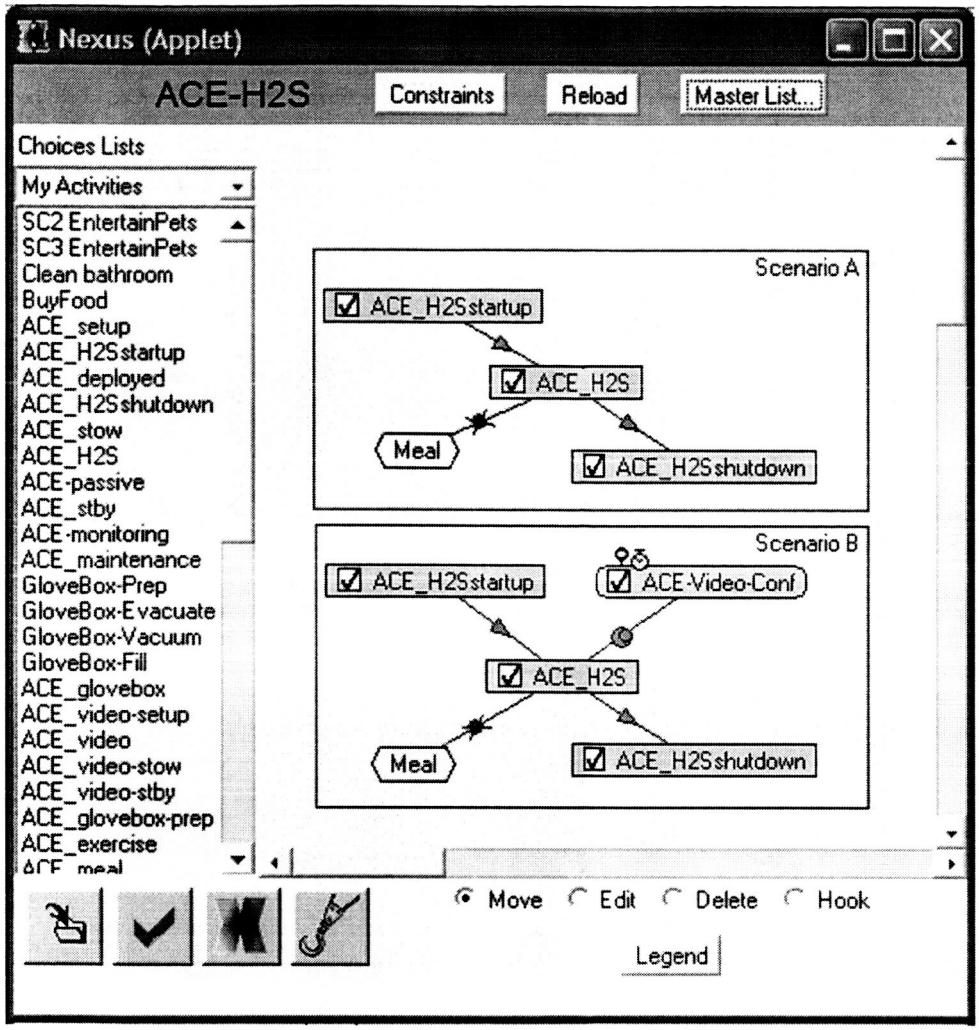
Introduction

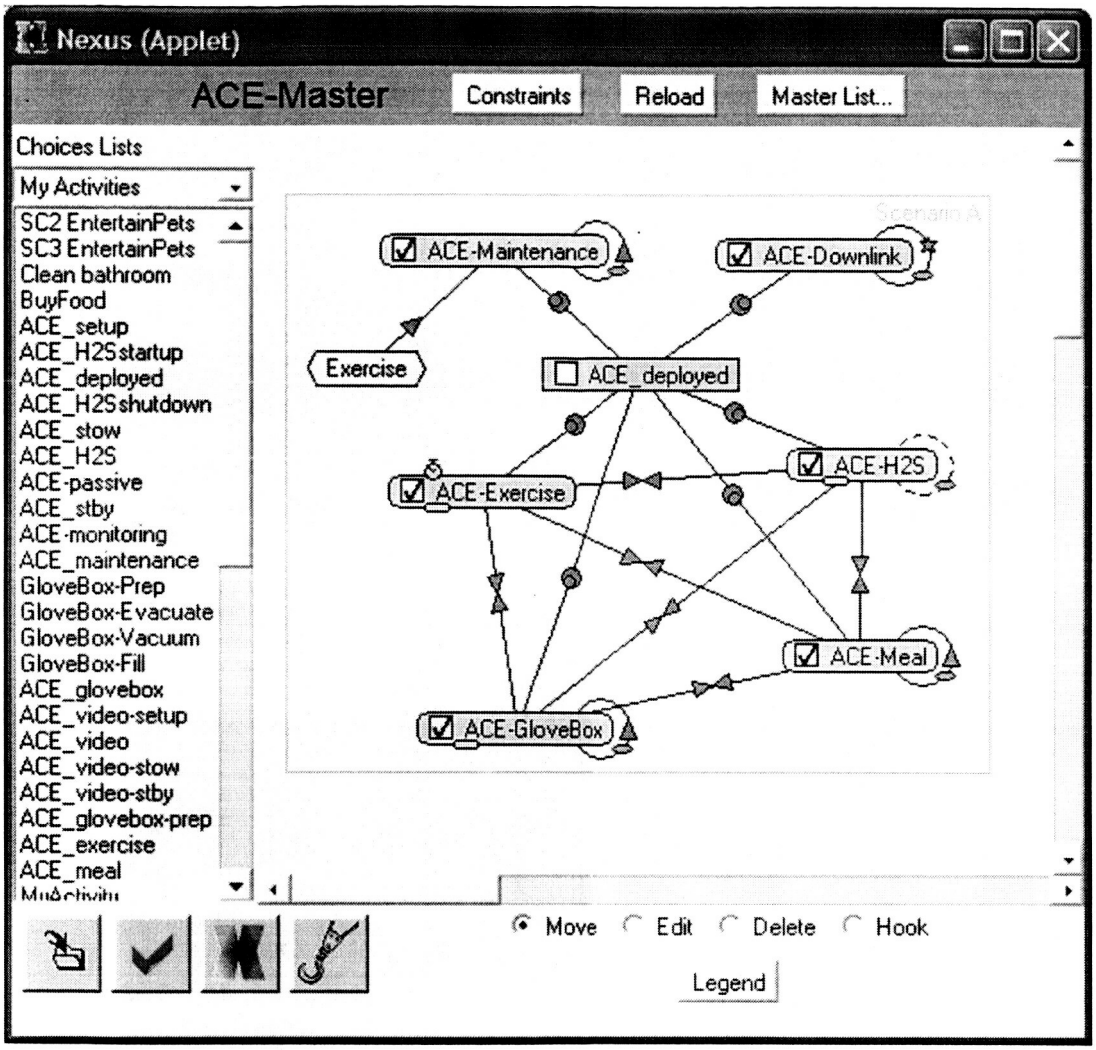
This appendix contains selected screen shots for demonstrations of Nexus. The demonstration has two parts –

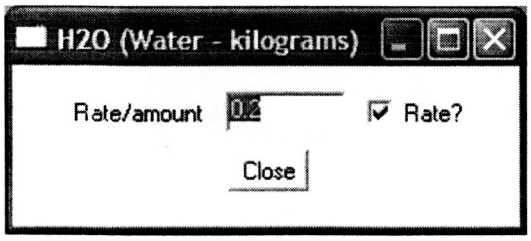
- Multi-user configuration— A personal computer is connected, via the internet, to a web server at MSFC. Typical demonstrations include building and editing models, submitting scheduling request, reviewing the results of the request, and viewing the complete timeline.
- Personal Data Assistant— A PDA is connected, via a wireless access point and the internet, to a web server at MSFC. Demonstrations include submitting a pre-prepared scheduling request and viewing the results.

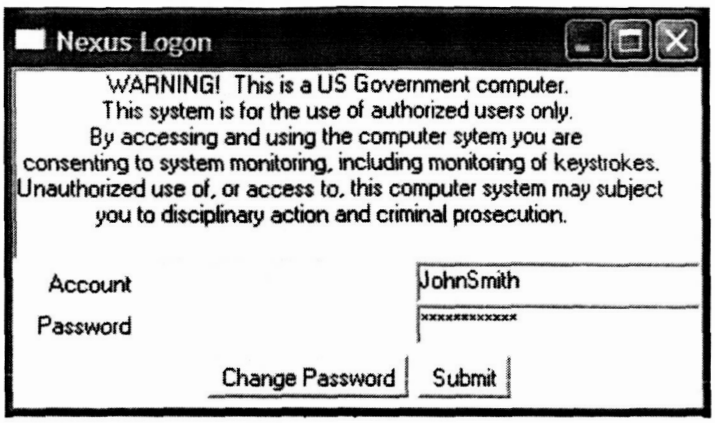


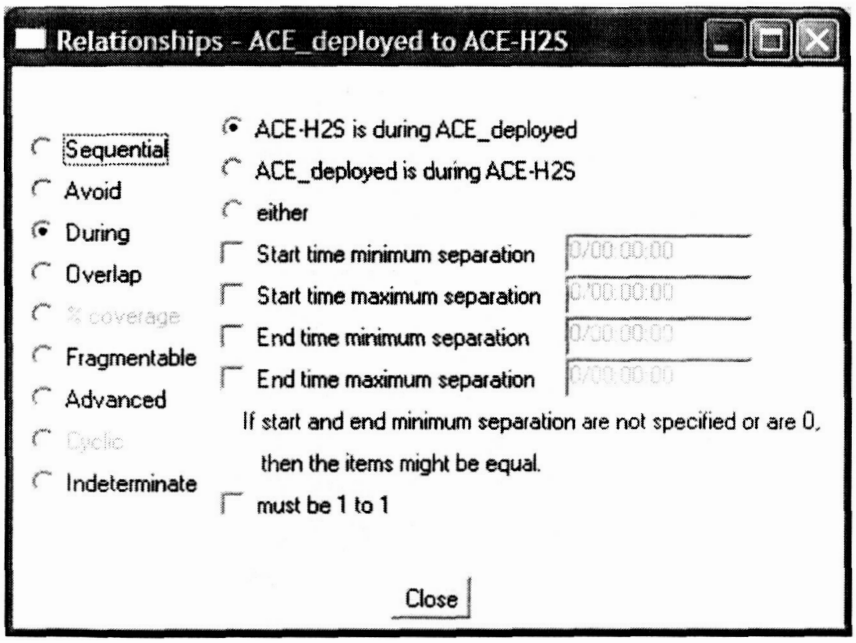
All screenshots are showing fictional data
John Jaap


Nexus (Applet)
ACE-H2S
Constraints
Reload
Master List...
Choices Lists
My Activities
SC2 EntertainPets
SC3 EntertainPets
Clean bathroom
BuyFood
ACE_setup
ACE_H2Sstartup
ACE_deployed
ACE_H2Sshutdown
ACE_stow
ACE_H2S
ACE-passive
ACE_stby
ACE-monitoring
ACE_maintenance
GloveBox-Prep
GloveBox-Evacuate
GloveBox-Vacuum
GloveBox-Fill
ACE_glovebox
ACE_video-setup
ACE_video
ACE_video-stow
ACE_video-stby
ACE_glovebox-prep
ACE_exercise
Scenario A
ACE_H2Sstartup
ACE_H2S
Meal
ACE_H2Sshutdown
Scenario B
ACE_H2Sstartup
ACE-Video-Conf
ACE_H2S
Meal
ACE_H2Sshutdown
Move
Edit
Delete
Hook
Legend

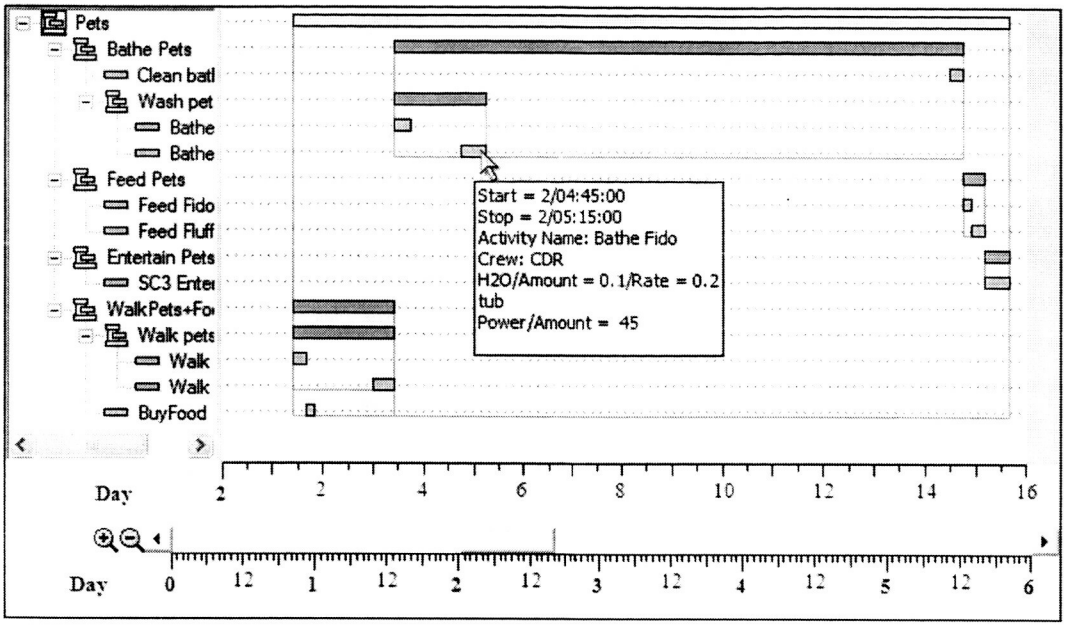

Nexus (Applet)
ACE-Master
Constraints
Reload
Master List...
Choices Lists
My Activities
SC2 EntertainPets
SC3 EntertainPets
Clean bathroom
BuyFood
ACE_setup
ACE_H2Sstartup
ACE_deployed
ACE_H2Sshutdown
ACE_stow
ACE_H2S
ACE-passive
ACE_stby
ACE-monitoring
ACE_maintenance
GloveBox-Prep
GloveBox-Evacuate
GloveBox-Vacuum
GloveBox-Fill
ACE_glovebox
ACE_video-setup
ACE_video
ACE_video-stow
ACE_video-stby
ACE_glovebox-prep
ACE_exercise
ACE_meal
Scenario A
ACE-Maintenance
ACE-Downlink
Exercise
ACE_deployed
ACE-H2S
ACE-Exercise
ACE-Meal
ACE-GloveBox
Move
Edit
Delete
Hook
Legend


H2O (Water - kilograms)
Rate/amount
Rate?
Close


Nexus Logon
WARNING! This is a US Government computer.
This system is for the use of authorized users only.
By accessing and using the computer sytem you are
consenting to system monitoring, including monitoring of keystrokes.
Unauthorized use of, or access to, this computer system may subject
you to disciplinary action and criminal prosecution.
Account
JohnSmith
Password
Change Password
Submit


Relationships - ACE_deployed to ACE-H2S
Sequential
Avoid
During
Overlap
% coverage
Fragmentable
Advanced
Cyclic
Indeterminate
ACE-H2S is during ACE_deployed
ACE_deployed is during ACE-H2S
either
Start time minimum separation
Start time maximum separation
End time minimum separation
End time maximum separation
If start and end minimum separation are not specified or are 0,
then the items might be equal.
must be 1 to 1
Close

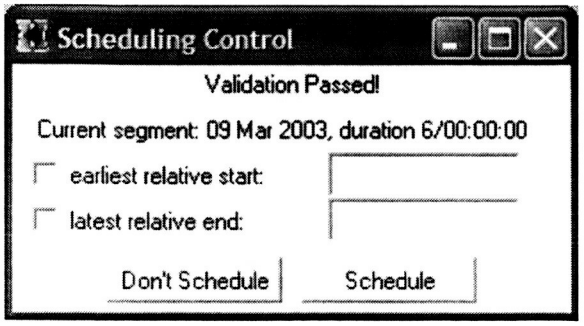
Scheduling Report

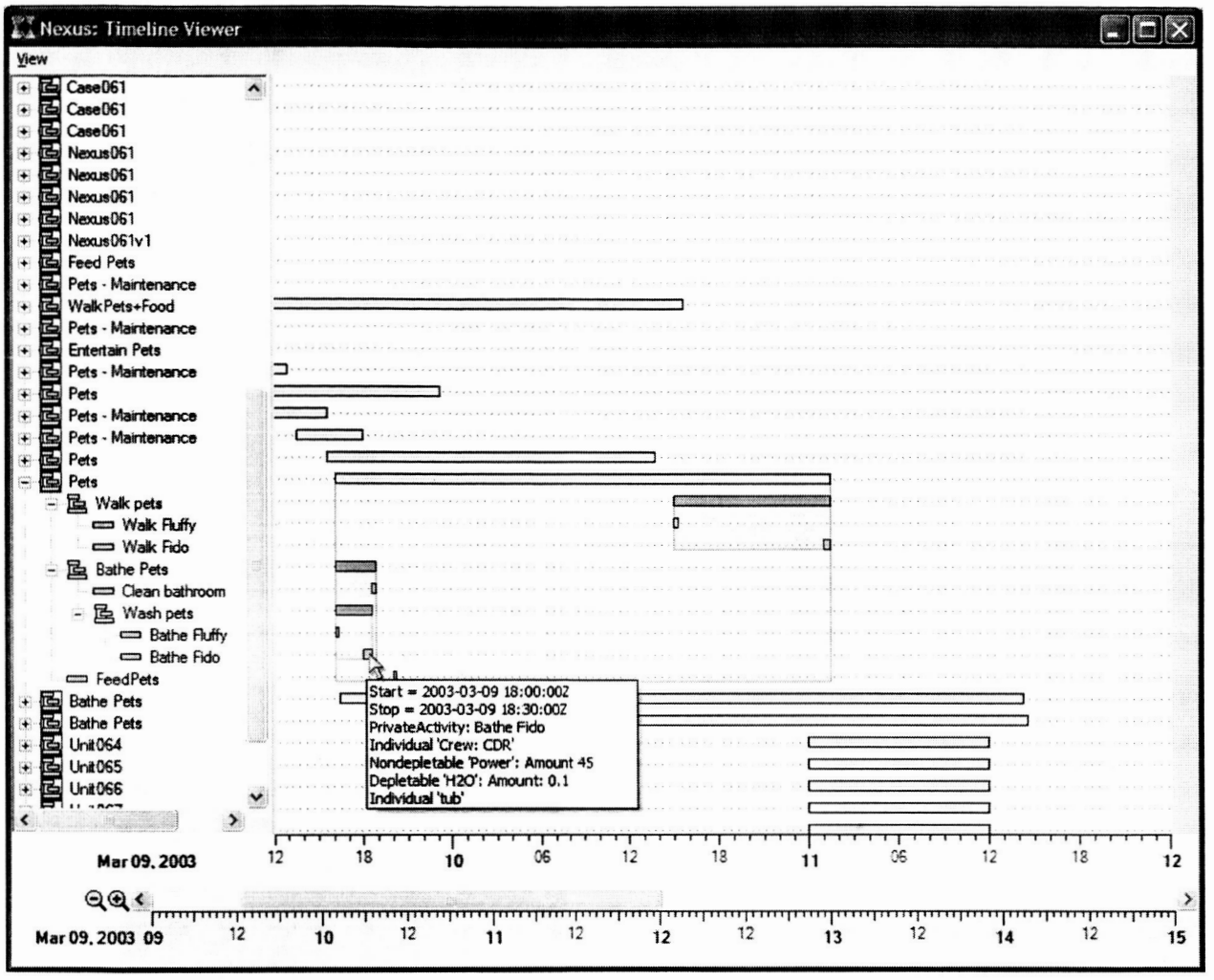


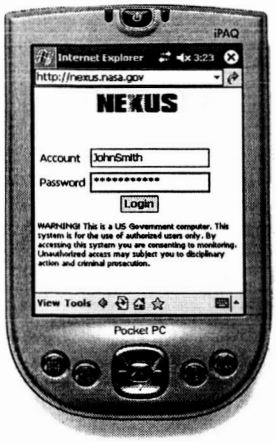
Account name: John
ID: 1061841120609

Scheduling Results for Initiating Sequence ID of 1061841120609

- Sequence `Pets` key: 359, parent: 1061841120609
  (scenario#1) scheduled: (2/01:25:00, 2/15:40:00)
  - Sequence `Bathe Pets` key: 360, parent: 359
    (scenario#1) scheduled: (2/03:25:00, 2/14:45:00)
    - Activity `Clean bathroom` key: 361, parent: 360
      scheduled: (2/14:30:00, 2/14:45:00), duration 0/00:15:00
      Using individual resource: `Crew: CDR`




Nexus: Timeline Viewer
View
Case061
Case061
Case061
Nexus061
Nexus061
Nexus061
Nexus061
Nexus061v1
Feed Pets
Pets - Maintenance
WalkPets+Food
Pets - Maintenance
Entertain Pets
Pets - Maintenance
Pets
Pets - Maintenance
Pets - Maintenance
Pets
Pets
Walk pets
Walk Fluffy
Walk Fido
Bathe Pets
Clean bathroom
Wash pets
Bathe Fluffy
Bathe Fido
FeedPets
Bathe Pets
Bathe Pets
Unit064
Unit065
Unit066
Start = 2003-03-09 18:00:00Z
Stop = 2003-03-09 18:30:00Z
PrivateActivity: Bathe Fido
Individual 'Crew: CDR'
Nondepletable 'Power': Amount 45
Depletable 'H2O': Amount: 0.1
Individual 'tub'
Mar 09, 2003
12 18 10 06 12 18 11 06 12 18 12
Mar 09, 2003 09
12 10 12 11 12 12 12 13 12 14 12 15


iPAQ
Internet Explorer
http://nexus.nasa.gov
NEXUS
Account JohnSmith
Password
Login
WARNING! This is a US Government computer. This system is for the use of authorized users only. By accessing this system you are consenting to monitoring. Unauthorized access may subject you to disciplinary action and criminal prosecution.
View Tools
Pocket PC